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FIBERGLASS COMPOSITE FIREFIGHTING HELMET AND METHOD FOR MAKING A FIBERGLASS COMPOSITE FIREFIGHTING HELMET

BACKGROUND

The present invention relates to protective head gear and, more particularly, to fiberglass composite firefighting helmets and methods for making such fiberglass composite firefighting helmets.

It is known to construct the protective shells of firefighter helmets with various composite materials that are specially designed to protect the wearer of the helmet in extremely adverse environments, which typically includes high heat environments. In such high heat environments it is important that the helmet have relatively high heat reflectance characteristics to increase the amount of time it will take the firefighter to become overheated. Additionally, it is also important that the helmet be as light as possible to decrease the stress on the wearer of the helmet. Of course, it is important that any improvements to the heat reflectance and weight of the helmet not sacrifice the relative durability of the helmet and the helmet's ability to protect the wearer's head from concussive blows. Accordingly, there is always a need to improve the construction of such firefighter helmet shells to increase the heat reflectance capability of the helmet, the durability of the helmet and/or to reduce the weight of the firefighting helmet, without sacrificing any of the other protective attributes of the helmet.

SUMMARY

The present invention provides a composite firefighting helmet and a method for constructing the composite firefighting helmet in which the heat reflectance of the firefighting helmet is substantially increased, in combination with the overall weight of the helmet being reduced, while not sacrificing any of the durability or concussive protection of the helmet.

In a first aspect of the present invention, a method for fabricating a protective helmet includes the steps of: (a) providing a fiber-based filler, such as a fiberglass sheeting; (b) mixing course ceramic particles into a thermoset resin; (c) impregnating the resin/ceramic particle

mixture into the fiber-based filler; (d) forming or molding the impregnated fiber-based filler into a shape of a protective helmet; and (e) curing the resin mixture impregnated into the fiber-based filler. The course ceramic particles are preferably created by chopping ceramic material to an average size ranging from approximately 7 microns to approximately 8 microns. Preferably, the amount of course ceramic particles that is mixed into the thermoset resin is approximately 10% to approximately 20% of the weight of the thermoset resin.

The presence of the ceramic particles in the composite helmet substantially reduces the heat reflectance of the helmet; while also reducing the overall weight of the helmet, since the ceramic material weighs less than the portion of resin material that the ceramic material is being used in place of. Finally, because the ceramic particles are course, they will not all flow to "low spots" in the helmet during the curing process. The course ceramic particles will remain entangled with, and caught on the fibers of the fiber-based filler during the curing process, thereby ensuring a more even distribution of the ceramic particles throughout the finished helmet.

It is also preferred that the curing step includes the step of providing an appropriate amount of pressure and temperature to the impregnated fiber-based filler, for a sufficient period of time, such that the resin mixture flows around the fibers of the fiber-based filler and bonds to the fibers of the fiber-based filler. Such an appropriate temperature range will be from approximately 75° to approximately 350° F.; such an appropriate applied pressure range will be from approximately 70 psi to approximately 800 psi; and such a sufficient time period will range from approximately 30 seconds to approximately 10 minutes. In a specific embodiment, the appropriate temperature is approximately 128°F. and the sufficient period of time is approximately 8 minutes.

The resin can be a polyester, vinyl ester or an epoxy; all of which will include a curing agent, such as a catalyst, if necessary. In a specific embodiment, the thermoset resin is a "pure" vinyl ester, in which the catalyst is preferably mixed therein immediately prior to the impregnating step.

The fibers in the fiber-based filler may include fiberglass fibers, aramid fibers, azol fibers, any combination of such fibers, or any fiber or fiber combination having the appropriate reinforcing and structural characteristics necessary for the helmet's intended use. In a specific embodiment, the fiber-based filler includes a fiberglass mesh or batting sandwiched by at least a pair of woven or non-woven, thin fiberglass sheets.

Sub A1 ~~It is another aspect of the invention to~~ provide a method ~~for fabricating a protective~~ helmet that includes the steps of: (a) providing a male mold component; (b) providing a female mold component; (c) positioning a fiber-based filler between the male and female mold components; (d) mixing course ceramic particles into a thermoset resin, providing a resin mixture; (e) positioning the resin mixture between the male and female mold components; (f) curing the fiber-based filer and resin mixture together by pressing the male and female mold components together for a curing time. Preferably, the step of positioning the resin mixture between the male and female mold components includes a step of coating at least a portion of the fiber-based sheeting with at least a portion of the resin mixture. It is also preferred that the method include a step of coating at least a portion of one of the male and female mold components with another portion of the resin mixture, prior to positioning the fiber-based filler between the male and female mold components. This pre-coating of the resin mixture helps to reduce the propensity for the ceramic particles to flow to the "low spots" in the helmet during the curing stage; and therefore, this pre-coating step is especially useful for resin mixtures utilizing a ceramic particle that is not as course as that provided in the preferred embodiment.

Therefore, it is yet another aspect of the present invention to provide a method for fabricating a protective helmet, comprising the steps of: (a) providing a male mold component; (b) providing a female mold component; (c) mixing ceramic particles (which may or may not be course) into a thermoset resin, providing a resin mixture; (d) coating at least a portion of a first one of the male and female mold components with a first portion of the resin mixture; (e) after the coating step, positioning a fiber-based filler over the first portion of the resin mixture in the first mold component; (f) after the positioning step, applying a second portion of the resin

mixture over the fiber-based filler; and (g) curing the fiber-based filler and resin mixture together by pressing the male and female mold components together for a curing time.

It is yet another aspect of the present invention to provide a method for fabricating a protective helmet that includes the steps of: (a) providing a male mold component; (b) providing a female mold component; (c) mixing course ceramic particles into a thermoset resin, providing a resin mixture; (d) coating at least a portion of a first one of the male and female mold components with a first portion of the resin mixture; (e) after the coating step, positioning a fiber-based sheeting over the resin mixture coating in the first mold component; (f) after the positioning step, applying a second portion of the resin mixture over the fiber-based sheeting; and (g) curing the fiber-based sheeting and resin mixture together by pressing the male and female mold components together for a curing time.

Preferably, the curing step includes a step of pressing the male and female mold components together for an appropriate amount of pressure and temperature, for a sufficient period of time, such that the resin mixture flows around the fibers of the fiber-based sheeting and bonds to the fibers of the fiber-based sheeting.

It is yet another aspect of the present invention to provide a protective helmet that includes a fiber-based filler impregnated with a cured resin and coarse ceramic particle mixture, where the impregnated fiber filler is formed into a shape having at least a bowl portion. Preferably, the cured resin coarse ceramic particle mixture includes chopped ceramic particles having an average size ranging from approximately 7 microns to approximately 8 microns; and preferably the mixing step includes the step of mixing an amount of the ceramic particles into the thermoset resin, where this amount is approximately 10 to approximately 20% of the weight of the thermoset resin.

While the preferred embodiments of the invention pertain to the fabrication of a fiber-composite protective helmet, it will be apparent to those of ordinary skill that the methods of the present invention may be used to fabricate relatively light-weight, heat-reflective fiber-composite objects useful for other purposes. For example, such fiber-composite objects fabricated

according to the present invention may include, but are certainly not limited to: (a) protective objects adapted to be worn in hazardous duty environments, such as knee, elbow, shin, and forearm protectors; (b) fire-walls for vehicles; (c) or any other known or future application where heat blockage is desired.

It is therefore, yet another aspect of the present invention to provide a method for forming a relatively rigid, fiber-composite object that includes the steps of: (a) providing a fiber-based filler, such as a fiber-based sheeting; (b) mixing coarse ceramic particles into a thermoset resin, providing a resin mixture; (c) impregnating the resin mixture into the fiber-based filler; (d) forming the impregnated fiber-based filler into a desired shape; and (e) curing the resin mixture to form a relatively rigid, fiber-composite object.

Accordingly, it is an object of the present invention to provide a method for fabricating fiber-composite objects, such as firefighter helmet shells, that are relatively lightweight and that have relatively high heat reflectance characteristics. It is another object to improve the construction of firefighter helmet shells to increase the heat reflectance capability of the helmet, the durability of the helmet and/or to reduce the weight of the firefighting helmet, without sacrificing any of the other protective attributes of the helmet. These and other objects and advantages of the present invention will be apparent from the following description, the attached drawings and the appended claims. It is to be understood, however, that it is not necessary to meet any or all of the stated advantages or objects of the present invention disclosed herein in order to fall within the scope of any claims, since the invention is defined by the claims and since inherent and/or unforseen advantages of the present invention may exist even though they may not be explicitly discussed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates the various components of a "glass back" component along with a negative mold for constructing the glass back component, the glass back component providing

the fiber-based filler for the construction of the protective helmet according to a preferred embodiment of the present invention;

Fig. 2 provides a perspective view of a preferred fiberglass sheeting construction for use with the present invention;

Fig. 3 is a schematic, perspective view of a mold for use with the process of the present invention;

Fig. 4 illustrates a process step of the preferred embodiment of the present invention utilizing the mold component;

Fig. 5 illustrates another process step of the preferred embodiment of the present invention utilizing the mold component;

Fig. 6 illustrates another process step of the preferred embodiment of the present invention utilizing the mold component; and

Fig. 7 illustrates another process step of the preferred embodiment of the present invention utilizing the mold component.

DETAILED DESCRIPTION

As shown in Fig. 1, a fiber-based filler, which, in the preferred embodiment is a "glass back" component 10 is constructed within a shell 12. The shell 12 is essentially a negative impression of an outer surface of a firefighting helmet; including a bowl portion 14 and a brim portion 16, and where the inner surface of the bowl portion includes a plurality of grooves 18 that are used for creating the ribs on the glass back 10, as will be discussed below.

The first step in fabricating and constructing the glass back 10 is to insert a plurality of strips of fiberglass sheeting 20 into the corresponding grooves 18 of the shell 12. Next, a bowl-shaped veil 22 is inserted into the shell 12 and attached to the ribs 20 with a light adhesive spray. In the exemplary embodiment, the veil 22 is composed of at least two segments 22a and 22b to reduce the number of wrinkles and irregularities in the glass back 10 and to ease in the

manufacturing process. Next, the major fiberglass sheeting material 24 is inserted into the shell 12 and attached to the veil 22 and ribs 20 by a light adhesive spray.

Referring to Fig. 2, the major fiberglass sheeting 24 and the strips of fiberglass sheeting 20 are, in the exemplary embodiment, composed of an inner layer of mesh-like, very fine, fiberglass fibers 26 sandwiched between a pair of woven or non-woven thin fiberglass sheets of material 28. Preferably, the mesh-like layer 26 is approximately .070 inches thick and the total sheeting is approximately .090 inches thick. Such a <u>fiberglass sheeting material is commercially available from Owens Corning</u>.

Sub A2 ~~Referring back to Fig. 1, in the exemplary embodiment, the major sheeting 24~~ is broken up into at least two segments 24a, 24b where each segment preferably includes a brim portion and a bowl portion corresponding to the brim and bowl portions of the firefighting helmet. Again, the multiple segments 24a, 24b, of the major sheeting 24 helps to reduce the number of wrinkles and irregularities in the glass back 10 and to ease in the glass-back assembly process. Finally, a woven glass cloth 26 is applied over the primary sheeting 24 with a light adhesive to act as a rebar. In the exemplary embodiment, the woven glass cloth is comprised of at least two segments 26a, 26b to control wrinkles and to simplify the assembly process. When all of the components 20, 22, 24 and 26 of the glass back 10 are fastened together, the glass back 10 is removed from the shell 12 and saved for use as a fiber-based filler in the manufacturing process of the firefighting helmet as will be discussed below.

It should be apparent that the use of fiberglass sheeting and the construction of a glass back 10 are merely the exemplary means to provide a fiber-based filler used as reinforcement in the composite helmet, and that it is within the scope of the invention to utilize other forms of fiber-based filler (such as loose fibers, for example). Also, while the fiber-based filler is preferably fiberglass, it is within the scope of the invention to utilize other types of reinforcing fibers such as, for example, aramid fibers, azol fibers, or any combination of glass, aramid or azol fibers.

As shown in Fig. 3, the mold 32 used for fabricating the firefighting helmet of the preferred embodiment of the present invention includes a female mold component 34 and a male mold component 35. The female mold component 34 includes an annular recess 36 for forming the brim of the firefighting helmet therein and a hemispherical indentation 38 forming the bowl portion of the firefighting helmet therein. The hemispherical bowl portion also includes a plurality of notches 40 for forming the corresponding plurality of ribs that will appear on the outer surface of the bowl portion of the firefighting helmet. The male mold component 35 will include a slightly raised brim portion 42 and a hemispherical dome 44 extending therefrom for being received within the hemispherical cavity 38. The recess 36, hemispherical indentation 38 and notches 40 of the female mold component 34 and the raised portion 42 and dome 44 of the male mold component 35 provide active surfaces for molding the firefighter helmet therebetween during the curing step, described below.

A preliminary step in the manufacturing process is to create a resin and course ceramic particle mixture. Generally, this step involves mixing course ceramic particles into a thermoset resin. Preferably, the course ceramic particles are created by chopping a ceramic material down to an average size of approximately 7 to approximately 8 microns. It is within the scope of the invention, however, to chop the ceramic into course particles having an average size ranging from approximately 3 microns to approximately 1000 microns. In the exemplary embodiment, the median particle size of the chopped ceramic particles is approximately 7.6 microns. Such chopped ceramic particles are available from Ceramic Technologies Corporation, of Howley IA, having a product ID KZ-009.

Preferably, the resin is a pure vinyl ester; which, in the preferred embodiment is a 99835 resin. Nevertheless, it is within the scope of the invention to use other suitable thermoset or curable resins such as polyesters, vinyl esters or epoxies, or any combination of such.

Preferably, the amount of coarse ceramic particles to mix into the thermoset resin ranges from approximately 10% to approximately 20% of the weight of the thermoset resin; and in the exemplary embodiment, 4 ½ lbs of coarse ceramic particles will be mixed into every 30 lbs of

thermoset resin (approximately 15% of the weight of the thermoset resin). Nevertheless, it is within the scope of the invention to use any suitable ratio of ceramic particles and thermoset resin. It is also preferred that, once the coarse ceramic particles are mixed into the thermoset resin, the mixture be stirred constantly until it is applied to the fiber-based filler or within the mold as will be described below. This constant mixing will ensure that the coarse ceramic particles remain substantially evenly distributed throughout the thermoset resin. It is also preferred that a suitable catalyst will also be added to the mixture immediately before the mixture is first applied to the fiber-based filler or within the mold as described below. With the exemplary embodiment, approximately 5ml of suitable catalyst is added to the 34 ½ lbs of mixture prior to application. Suitable dyes or colors may also be added to the mixture to achieve a desired color for the finished product.

As illustrated in Fig. 4, a first step in the process of fabricating a firefighter helmet according to a exemplary embodiment of the present invention is to a first coat of the catalyzed resin mixture to the active surfaces of 36, 38 & 40 of the female mold component 34. The amount of the resin mixture to use in this first coat is preferably approximately 1/4 to 1/3 of the total resin mixture that will be used for the entire helmet. As illustrated in Fig. 5, a next step in the process is to place the glass back 10 (the construction of which is described above) over the first coat 46 of the resin mixture in the female mold component 34, such that the brim portion of the glass back 10 received within the annular recess 36 and such that the bowl portion of the glass back 10 is received within the hemispherical indentation 38. Of course the ribs 20 of the glass back 10 are received within the notches 40 of the female mold component 34. As shown in Fig. 6, a next step in the process is to coat the exposed surfaces of the glass back 10 in the female mold 34 with the remainder of the resin mixture 48 that will be used to fabricate the entire helmet. Finally, as shown in Fig. 7, a next step in the process is to activate the mold device such that the male mold component 35 and the female mold component 34 press against each other for a sufficient amount of time, applying a sufficient pressure and temperature, such that the thermoset resin mixture flows around the fibers of the glass block 10 and begin to cure so as to

form a substantially rigid shell for a firefighter helmet. Once sufficiently cured, the mold components can be opened again and the shell of the firefighter helmet may be removed therefrom. Subsequently, the shell can be trimmed (if necessary) and the final helmet components, such as webbing, face mask, etc. can be assembled thereto.

The sufficient temperature applied by the mold may range from approximately 75° to approximately 350° F, the appropriate pressure applied by the mold may range from approximately 70 to approximately 800 psi; and the sufficient amount of time to apply such appropriate pressure and temperature ranges from approximately 30 seconds to approximately 10 minutes. In the exemplary embodiment, the appropriate pressure is approximately 125 psi, the appropriate temperature is approximately 128°F and the appropriate amount of time to apply such pressure and temperature is approximately 8 minutes.

The presence of the ceramic particles in the finished composite helmet substantially reduces the heat reflectance of the helmet; while also reducing the overall weight of the helmet, since the ceramic material weighs less than the portion of resin material that the ceramic material is being used in place of. Finally, because the ceramic particles are course, they will not all flow to "low spots" in the helmet during the curing process. The course ceramic particles will remain entangled with, and caught on the fibers of the fiber-based filler during the curing process, thereby ensuring a more even distribution of the ceramic particles throughout the finished helmet. Furthermore, the pre-coating of the resin mixture to the mold component (Fig. 4) helps to reduce the propensity for the ceramic particles to flow to the "low spots" in the helmet during the curing stage; and therefore, this pre-coating step is especially useful for resin mixtures utilizing a ceramic particle that is not as course as the chopped ceramic particles provided in the preferred embodiment.

While the exemplary embodiments of the invention, described above, pertain to the fabrication of a fiber-composite protective helmet, it will be apparent to those of ordinary skill that the methods of the present invention may be used to fabricate relatively light-weight, heat-reflective fiber-composite objects useful for other purposes. For example, such fiber-composite

objects fabricated according to the present invention may include, but are certainly not limited to: (a) protective objects adapted to be worn in hazardous duty environments, such as knee, elbow, shin, and forearm protectors; (b) fire-walls for vehicles; or (c) any other known or future application where heat blockage is desired. Such relatively rigid, fiber-composite objects may be constructed according to the following steps: providing a fiber-based filler, such as a fiber-based sheeting; mixing coarse ceramic particles into a thermoset resin; impregnating the resin mixture into the fiber-based filler; forming the impregnated fiber-based filler into a desired shape; and curing the resin mixture to form a relatively rigid, fiber-composite object. The impregnating, forming and curing steps are preferably performed by a mold providing an appropriate amount of pressure and temperature, for a sufficient amount of time, on the combination of the fiber-based filler and resin mixture.

Following from the above description and summaries, it should be apparent to those of ordinary skill in the art that, while the designs and processes herein described constitute preferred embodiments of the present invention, it is to be understood that the invention is not limited to these precise designs and processes, and that changes may be made therein without departing from the scope of the invention as defined by the claims. Additionally, it is to be understood that the invention is defined by the claims and it is not intended that any limitations or elements describing the exemplary embodiments herein are to be incorporated into the meaning of the claims unless such limitations or elements are specifically listed in the claims. For example, it is to be understood that it is within the scope of the invention to utilize any size of coarse ceramic particles, unless such sizes are specifically claimed; it is to be understood that it is within the scope of the invention to cure the resin material (i.e., change the properties of the resin material) without application of the specific temperatures and/or pressures listed above, unless such temperatures and/or pressures are specifically claimed; and it is also to be understood that the listed times for applying such temperatures is not intended to be limiting unless specifically claimed.

What is claimed is: